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## (54) Optical fibre cable and method of manufacture

(57) In order to preserve the intrinsic optical characteristics of optical fibres in an optical cable unit, there is provided a loose housing about the optical fibre(s) 11. This results in lower excess cabling losses than tight buffer, compact fibre optic cable designs. The loose housing comprises a tape (12) formed, possibly helically, into a tube about the optical fibres. A plurality of cable units are combined to form an optical fibre cable.



Fig. 2.

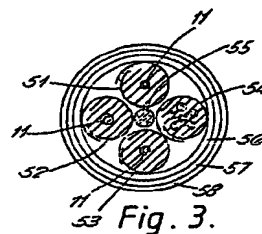


Fig. 3.

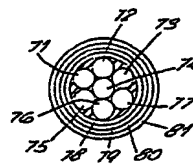
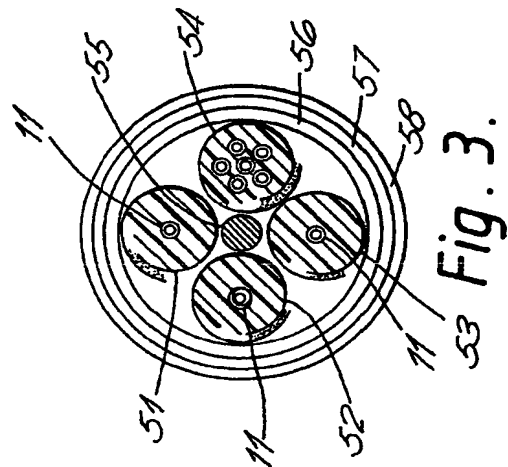
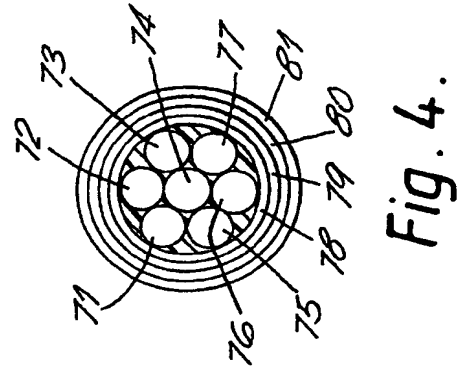
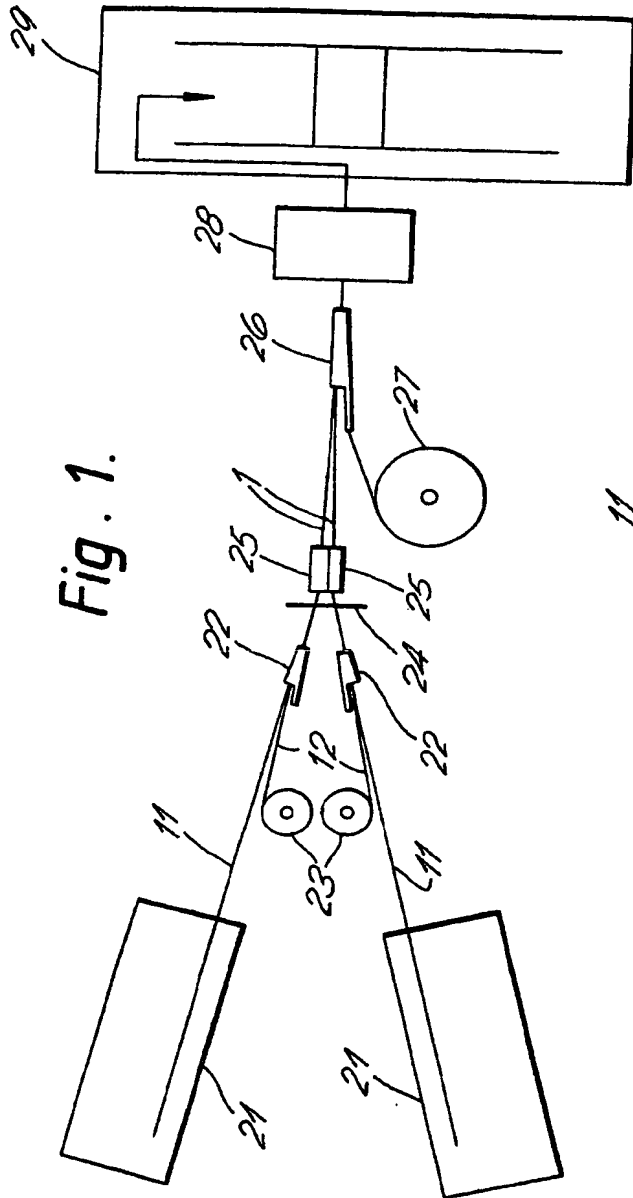


Fig. 4.

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## SPECIFICATION

## Optical fibre cable and method of manufacture

5 The present invention relates to an optical fibre cable and a method of manufacture of such a cable. More particularly, the present invention relates to an optical fibre cable and method of manufacture of such a cable of the type having a central strength member and one or more optical fibres laid about the central strength member in a protected manner.

10 Optical fibres have become a desirable information transmitting medium due to their broad bandwidth capacity and small physical size and weight relative to metal electrical conductors. A number of characteristics of optical fibers including their susceptibility to breakage and their bending and stress losses pose serious problems in their use. It is, therefore, necessary to find suitable means to protect the fibres.

One approach to the above problems has been to start with a plurality of optical fibres and to form them into linear arrays packaged in ribbon-like structures. This approach is described in detail in U.S. Patent No. 4,129,468, issued December 12, 1978. The requirements imposed on such optical fibre ribbons include the need to provide mechanical stripability for ease of cable termination and splicing; the need for small size; the need for resistance to breakage when subjected to tensile stress; the need for individual fibre identification within the ribbon; and, the need to protect the ribbon from distorting forces which may cause deterioration of the optical signal.

35 After forming these ribbons, they are used to form optical cables. It has been asserted that these ribbons provide adequate protection for the optical fibres when used for information transmission. Various processes for manufacturing such an optical cable are described in U.S. Patents 3,937,559; 4,110,001; 4,138,193 and 4,146,302. As appears in each of these patents, it is still necessary to form the ribbon-like structure prior to the cabling operation. Indeed, it is specifically stated in each of these 45 patents that forming of the ribbon-like structure reduces the risk of injury to the optical fibres during the cabling operation. The drawback to such a requirement is particularly significant when a cable having only a few fibres is required. It is an unduly burdensome procedure to first produce ribbons and then make a cable to carry the ribbon. The cabling of the optical fibre ribbons is a complicated and expensive procedure, even after the ribbons have been assembled. Cabling of these ribbons requires 50 the use of planetary stranders at least for the laying of strength members into the required extruded sheath. Such equipment is expensive; and hence, contributes significantly to the overall cost of the cabling operation.

60 It has been proposed to avoid the requirement for a multistep cabling process by incorporating one or more optical fibres into a cable as the cable is formed. Such procedures are described in U.S. Patent Nos. 4,155,963; 4,154,049; and 4,205,899.

65 These patents disclose the extrusion of a profiled

central member having grooves into which optical fibres are laid, followed by closure of the groove, thereby enclosing the fibre in a longitudinally extending chamber. U.S. Patent No. 4,199,224 is similar and adds a separate central strength member. These methods permit optical fibres to be laid into the open channels as the cable is manufactured; hence, eliminating the necessity of first manufacturing an optical fibre ribbon. The methods disclosed in 75 these patents require expensive machinery and a large amount of floor space for cabling of optical fibre. As a result of the expenses associated with the machines and dedicated floor space, these are expensive cabling techniques.

80 Another approach for cabling of optical fibres is disclosed in U.S. Patent No. 4,153,332 issued May 8, 1979. This patent explains that a cable may be formed by winding unitary elements having an adhering sheath on a supporting core. When this structure is bent on a mandrel having a small 85 bending radius, the unitary element is compressed in the inner portion facing the mandrel and is stretched in the outer portion. This occurs because of the fact that the friction between the element and the core about which it is wound prevents the element from sliding significantly with respect to the core. The optical fibre or fibres contained in the unitary element are subjected to compressive and tension stresses. To overcome this drawback, it is recommended that the fibres be centered in a tubular sheath. This patent discloses that, at the present state of the art, no processes are known for producing unitary optical fibre elements which permit a perfect centering of the optical fibre with 95 respect to the sheath. This is especially true when the sheath has a diameter much greater than that of the fibre. When the fibre is not centered, it is well known to those skilled in the art that the tension or compressive stress on the fibre, when the unitary element is subjected to flexing, is proportional to the distance of the optical fibre from the neutral axis of the unitary element and inversely proportional to the bending radius of the element. To compensate for this, the fibres may be longer than the length of the corresponding surrounding sheath by either winding 100 the fibres around a central core within the sheath or by imparting a helical bend to the fibres and laying them loosely within the sheath. The patent goes on to assert that the provision of a tubular sheath into which the optical fibre is inserted provides a protective structure which shields the surface of the fibre from radial compressive force and from contact with corrosive substances.

Another approach which has been proposed for providing a protective cable structure for optical fibres is disclosed in U.S. Patent No. 4,235,511 issued November 25, 1980. This patent describes a cabling technique wherein a central strength member is surrounded by elements which define chambers running the length of the strength member and which are covered in order to enclose an optical fibre laid into the chamber. The patent discloses folded splicing tape helically wrapped about the central strength member for formation of the chambers.

130 All of the above described cables suffer from one

or more of the problems including high expense in cable manufacture, susceptibility to fibre breakage during cabling or cable laying operations, and poor optical transmission characteristics.

- 5 In order to preserve the intrinsic optical characteristics of optical fibres in an optical cable unit, the present invention seeks to provide a loose housing about the optical fibres.

According to the invention there is provided an optical fibre cable unit, comprising a flexible tape formed into a cylindrical member such that the longitudinal edges thereof are in overlapping relationship forming a seam, and an optical fibre freely located in said cylinder.

- 15 This results in lower excess cabling losses than tight buffer, compact fibre optic cable designs. The loose housing may be formed of a plastics or metal tape formed into a tube. A plurality of cable units may be combined to form an optical fibre cable.

20 According to another aspect of the invention there is provided a method of manufacturing a fibre optic cable unit, comprising the steps of paying off and rotating one or more optical fibres, paying off a thin, flexible tape, and forming the tape into a cylindrical form extending around the optical fibre(s).

- 25 In order that the invention and its various other preferred features may be understood more easily, some embodiments thereof will now be described, by way of example only, with reference to the drawings, in which:

*Figure 1* illustrates a method of making a cable in accordance with the invention.

- 30 *Figure 2* is a cross-section of a first embodiment of optical fibre cable unit with a single optical fibre and constructed in accordance with the invention.

*Figure 3* is a cross-section of an optical fibre cable constructed in accordance with the invention and including four optical fibre cable units and a strengthening element.

- 40 *Figure 4* is a cross-section of another optical fibre cable constructed in accordance with the invention and including seven optical fibre cable units as illustrated in *Figure 2*.

Referring to the drawings, *Figure 1* shows the procedure for assembling an optical fibre cable unit 1 illustrated in *Figure 2*. One or more optical fibres 11 are paid off from a supply reel in such a way that it experiences no torsional stress. This can be accomplished by feeding the fibres 11 from conventional apparatus known as neutraliser payoffs 21. Narrow, then flexible tapes 12 of for example a plastics or metal are fed from fixed payoffs 23, that is, reels rotating about a fixed axis, to tape forming dies 22. As will be made clear hereinafter, the fibres 11 are rotated by the action of a single twist closer 29 containing a reel on which the cable is wound.

Each fibre 11 also passes through a tape forming die 22 where each flexible tape 12 is formed into a partial cylinder about its associated fibre or fibres, that is, the tapes are provided with an arcuate shape about an axis parallel to their longitudinal axis, but are not yet closed to form cylinders. The flexible tapes 12 are paid off at a speed equal to that of the fibres 11 and because of the rotation, their longitudinal edges extend in a generally helical manner

about the fibres. Each fibre 11 and its associated tape 12 then pass through a guide 24 and then a closing die 25 that is operative to overlap the longitudinal edges of the tape 12, thus forming a seam and closing the cylinder. The seam extends helically about the enclosed fibre or fibres.

- The internal diameter of the cylinders formed by tapes 12 are larger than the outer diameter of the fibres 11 so that each tape cylinder freely and loosely receives a fibre whereby the fibre is movable relative to the cylinder. Of course, if each cylinder contains more than one fibre, its internal diameter will be larger than the bundle of fibres therein so that these fibres are freely and loosely contained. Because of the helical lay of the tapes 12, the risk of the cylinders opening up is minimized. If desired, however, the seam may be secured by adhesives or heat treatment.

The closing dies 22 are arranged relatively close to each other so that the tubes exit from them in relatively close, side by side relationship whereupon they can be fed through an additional tape forming die 26 which also receives tape from a fixed payoff 27 so as to wrap a bundle of the tubes in a protective coating. The bundled, protected tapes can be covered with a binder in a suitable binder head 28 from where they are wound on the reel of the single twist closer 29.

- It will be understood that any number of tubes can be thus formed and that, with suitable modification, a central strength member can be fed into the centre of the tubes exiting from the closing dies 25 so that the additional tape applied at the forming die 26 forms a cable as generally shown in *Figure 3*.

In *Figure 2*, tape 12 is shown in its cylindrical form surrounding an optical fibre 11. The longitudinal edges are overlapped as shown in the overlap region 41 to form the helical seam previously mentioned. An adhesive 31 is also illustrated to help prevent the cylinder from opening. As noted previously, heat could be applied to the overlap region 41 causing the overlapping edges to bond or no securing means may be necessary.

- Figure 3* shows a composite optical cable having four of the optical cable units 1 described herein. These units are denoted as 51-54 in the drawing and will be referred to hereinafter as cylinders. The tape used to make these cylinders is preferably of the type sold under the Registered trademark MYLAR. Cylinders 51, 52 and 53 each contain one optical fibre 11; and cylinder 54 contains a plurality of fibres. An axial strength member 55 is centrally located with the cylinders 51-54 extending around it. In the preferred embodiment, the central member 55 is a solid or stranded wire. In alternative embodiments, the central member may be of an inorganic material such as glass yarn, aluminium yarn or glass fibre, or an organic material such as aramid yarn, graphite yarn or carbon yarn. The strength member may be insulated, impregnated or both with any suitable material, polyethylene or epoxy being exemplary.

The cylinders 51-54 are helically arranged about the central member 55 and an outer tape 56 is applied to hold cylinders 51-54 in place and to serve as a heat barrier during the jacketing operation. In

the event that a filling compound is provided in the cylinders, the outer tape will serve to prevent the compound from dripping during manufacture.

- In addition to the foregoing, the cable may be
- 5 provided with a metallic water barrier 57 which has a jacket 58 extruded thereover. If the intended use is in an environment where rodents may be a problem, a high strength outer protective layer (not shown) of metal may be provided.
  - 10 The optical cable designed in accordance with the invention is subjected to minimal excess cabling loss and provides improved flexibility over present cable designs. In the event that a high fibre count cable is required, a plurality of the units illustrated in Figure 3
  - 15 may be combined to form a helically wound bundle having at least one jacket thereover. A heat barrier is preferably provided as a filling compound. Figure 4 shows such an arrangement where seven cable units 71-77, all of which are the same as unit 1 illustrated
  - 20 in Figure 2, are enclosed in a heat barrier 78 consisting of a helical wrapping of tape, jacket 79 of polymeric material such as polyethylene, a rodent protection armour 80 consisting of, for instance, corrugated steel or bimetallic tape, and an outer
  - 25 polyethylene jacket 81. In the event that underground or underwater use is anticipated, it may be desirable to include a metallic water barrier tape in place of or in addition to one or more of the above described layers. It is preferable to have the water
  - 30 barrier externally adjacent the heat barrier in the location of the rodent barrier 80 of Figure 4.

#### CLAIMS

- 35 1. An optical fibre cable unit, comprising a flexible tape formed into a cylindrical member such that the longitudinal edges thereof are in overlapping relationship forming a seam, and an optical fibre freely located in said cylinder.
- 40 2. An optical fibre cable unit as claimed in claim 1 wherein the seam is helical.
3. An optical fibre cable unit as claimed in claim 1 or 2 wherein the longitudinal edges are secured together.
- 45 4. An optical fibre cable unit substantially as described herein with reference to Figure 2.
5. An optical fibre cable, comprising a plurality of optical fibre cable units as claimed in any one of claims 1 to 4 located adjacent a centrally located,
- 50 axially extending strength member, and a protective layer surrounding the cylindrical members.
6. An optical fibre cable as claimed in claim 4 wherein the optical fibre cable units are helically wrapped around the strength member.
- 55 7. An optical fibre cable substantially as described herein with reference to Figure 3 or 4.
8. A method of manufacturing a fibre optic cable unit, comprising the steps of paying off and rotating one or more optical fibres, paying off a thin, flexible
- 60 tape, and forming the tape into a cylindrical form extending around the optical fibre(s).
9. A method as claimed in claim 8, wherein the longitudinal edge of the tape is overlapped to form a helical seam.
- 65 10. A method as claimed in claim 9, wherein the

overlapping edge is seamed together.

11. A method as claimed in any one of claims 8 to 10, further comprising applying a heat barrier helically about the cylindrically formed tape.
- 70 12. A method as claimed in claim 11, further comprising applying a binder about the heat barrier.
13. A method of manufacturing a fibre optic cable in which a plurality of fibre optic cable units are formed simultaneously by the method as claimed in
- 75 any one of claims 8 to 12 and positioned side by side.
14. A method as claimed in claim 13, comprising the step of including an axial strengthening element among the fibre optic cable units and securing the resultant bundle together.
- 80 15. A method as claimed in claim 14, including the step of helically wrapping the fibre optic cable units around the strengthening element.
16. A method as claimed in any one of claims 8 to 15, further comprising applying an outer jacket by
- 85 polymer extrusion.
17. A method as claimed in any one of claims 8 to 16, further comprising applying a metallic moisture barrier.
18. A method of manufacturing a fibre optic
- 90 cable substantially as described herein with reference to Figure 1 of the drawings.

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